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Identifying Science Content Knowledge of Primary School Pre-Service Teachers at the Essential Physics Concepts

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ABSTRACT
Science Content Knowledge (SCK) teachers are one of the main things in providing science learning that follows scientific conceptions. One of the causes of misconceptions or inappropriate concepts that students have regarding science is the teacher. So, the purpose of this study is to identify pre-service teachers at primary school about the SCK. The research method used in this study is a quantitative method with a survey design. Data were collected from 131 participants from the Primary School Teacher Education Program in the early semester. The essential concepts in science (physics) used in the study are elementary and junior high school. The instrument is a multiple-choice test with four answers choices with 40 questions. The study finds that for almost every essential physics/science concept, the SCK of the pre-service teachers needs to be improved. This result contradicts our expectations considering the concepts being tested are for elementary and junior high schools. SCK is playing an important element in giving the quality of learning science and building and preparing students to meet the next educational level. Thus, teaching physics from an early age must be taught conceptually and presented with appropriate representations to make it easier for students to learn.

INTRODUCTION

Learning science will not separate from the science content knowledge (SCK) in every level of education form primary school until high school. Every school level gives some essential things to students to enhance their experience and ability in science learning. Primary school is a basic level to make students learn and understand SCK. Because of that, the SCK of primary school teachers has been an issue of great concern for educators and the science education community [1] [2] [3]. According to the literature, many primary school teachers have a deficit in science content knowledge that can hinder effective science teaching [4] [5].

The deficit about SCK will affect the quality of learning that teachers provide because it is a prerequisite for teaching science and if the teacher doesn't have a good SCK, it will make a limitation in

implementing effective science programs in primary school [1] [6]. Moreover, these situations could make science teaching predominantly teacher-centered with little room to facilitate students' creativity and curiosity [7]. The science learning will be useful if teachers can create a learning environment that challenges learners to develop a deep understanding of science concepts [3] [8].

Teachers' SCK or their understanding of science is one of the critical factors determining in the teaching process [9]. The teacher who does not have a good understanding of the content will not be able to deliver a quality lesson [10]. In Indonesia, primary school understanding is very complicated not only because they have to teach many subjects but also because of the variety of the teachers' educational background. Besides that, there is no standard formula for minimum science requirements for primary school teachers. However, teachers need to have a good understanding of basic concepts they are expected to teach [6] [11].

Lack of SCK often limits teachers' ability to plan effectively and deliver meaningful science lessons [12], and this makes teachers have difficulties in blending their pedagogical knowledge and SCK [10]. Even if the teachers have an excellent pedagogical understanding, they can develop an effective teaching strategy to deliver optimal science learning. Because SCK is very important to teachers or pre-service teachers in primary school and SCK needs to improve, starting with the pre-service teachers. SCK will affect the confidence teacher in teaching science [6]. Besides that, if a teacher does not have a good SCK, how will students learn and of course, it will have an impact on the learning given by the teacher to be less/not optimal [13]. So, the main aim of this study is to identify the level of pre-service teachers' understanding of the SCK of essential concepts?

METHOD

This research is a descriptive study using a survey method. Data were collected from 131 pre-service teachers in the Primary School Teacher Education Program at the beginning of the semester in Sumedang-Indonesia. The essential concepts in science (physics) used in the study is in elementary and junior high school. The instrument is a multiple-choice test with four answers choices with 40 questions. Table 1 will show detail about the instruments used in the study.

Table 1. Physics Concepts and Dissemination of Test

No	Physics Concepts	Test Number								Total
1.	Force	1	2	3	4	5	6	7		7
2.	Simple Mechanical Device	8	9	10						3
3.	Heat	11	12	13	14	15	16			6
4.	Optics	17	18	19	20	21				5
5.	Electricity	22	23	24	25	26	27	28	29	8
6.	Magnet	30	31	32	33	34				5
7.	Earth Science	35	36	37	38	39	40			6
					Total					40

The study participants were given two values, zero (0) if they gave a wrong answer and one (1) if they gave the correct answer. Participants' test results will be average and percentages. Then, the rate of results was entered into the category made by researchers in Table 2. Table 2 is a modification of the interpretation table developed by Malik [14]. And after giving the test, the participant will get some questioner about the test to know how they think about the essential physics science. The question in this part is 1) Did you understand the essential physics science in the instrument? 2) Can you mention the sequence of physics concepts from the most difficult to the easiest? 3) Are you ready to face the science content knowledge in primary school?

Table 2. Interpretation of Value or Percentage of Participants Test [14]

Range	Category
80-100	Very Good
70-79	Good
60-69	Enough
40-59	Less
30-39	Very Less

RESULTS AND DISCUSSIONS

The results of this study will be discussed, starting from participants' SCK based on the physics concepts then see how they respond to the SCK in essential physics concepts. The analysis of participants' SCK on physics concepts can be seen in Table 3.

Table 3. The Analysis of Participants' SCK and Category

Physics Concepts	Percentages (%)	Category
Force	48	Less
Simple Mechanical Device	60	Enough
Heat	46	Less
Optics	35	Very Less
Electricity	46	Less
Magnet	45	Less
Earth Science	52	Less

Based on Table 3, it can be seen that SCK pre-service teachers on essential physics concepts must be a common concern. In every physics concept, we can see that pre-service teacher fall into the "less" there is Force, Heat, Electricity, Magnet, and Earth Science. Concepts if Optics at "very less" categories, only Simple Mechanical Device in an "enough" category. It can be one indicator that the mastery of SCK in essential physics concepts needs to improve. In Indonesia, students learn the science subject (physics, biology, chemistry, etc.) for at least 9-12 years. However, the expectations do not match with reality. This research reveals that SCK needs more attention in the process of learning science at every education level. For a more detailed explanation of the sub-concepts being tested in this study, see table 4.

Table 4. The Participants' SCK and Category in Sub-Concepts

Physics Concepts	Sub-Concepts	Number	Percentages (%)	Category
Force	Mass and Weight	1	0.33	Very Less
	Gravitation	2	0.45	Less
	Newton Law 1	4	0.35	Very Less
		7	0.75	Good
	Newton Law 2	3	0.37	Very Less
	Newton Law 3	5	0.66	Enough
	Force Impact	6	0.46	Less
Simple Mechanical Device	Mechanical Advantages	8	0.63	Enough
		9	0.47	Less
		10	0.70	Good
Heat	Convention	11	0.47	Less
		14	0.34	Very Less
	Radiation	12	0.62	Enough
		15	0.31	Very Less
	Conduction and Convection	16	0.27	Very Less
	Heat and Pressure	13	0.54	Less

Physics Concepts	Sub-Concepts	Number	Percentages (%)	Category
Optics	Human eyes	17	0.01	Very Less
	Reflections	18	0.06	Very Less
	Refraction	19	0.46	Less
		21	0.68	Enough
	Lens	20	0.55	Less
Electricity	Static Electricity	22	0.76	Good
		23	0.56	Less
	Electricity Circuit	24	0.52	Less
		27	0.58	Less
		28	0.33	Very Less
		29	0.38	Very Less
	Conductor	25	0.42	Less
		26	0.48	Less
Magnet	Magnet Material	30	0.11	Very Less
	Magnet Characteristic	31	0.34	Very Less
		32	0.79	Good
		34	0.15	Very Less
	Magnetic Field	33	0.43	Less
Earth Science	Earth Rotation	35	0.56	Less
		38	0.57	Less
	Earth Revolution	36	0.60	Enough
	Moon Movement	37	0.37	Very Less
		39	0.61	Enough
	Sun Eclipse	40	0.43	Less

Table 4 shows that even the test is from primary and junior high school; most pre-service teachers can't give a correct answer. Those in the "Good" category are only four questions related to the Newton Law 1 concept, one item on Mechanical Advantages, Static Electricity, and Magnet Characteristic. Meanwhile, in the "Enough" category, there are only six questions related to the concept of Newton Law 3, one of the items on Mechanical Advantages, Heat (radiation), Optics (Refraction), earth science (Earth Revolution and Moon Movement). The majority of the test results found that most of their SCK in the science concept was in the "Less" and "Very Less" categories. And this problem not only in pre-service teachers in some research found that some teachers hold a similar understanding with their students [6] [15]. And at the last section or the response of the participants can be seen in Table 5.

Table 5. The Analysis of Participant's Response

Questions		Percentages (%)
Understand about the SCK	Yes	25.95
	Doubt	44.27
	No	29.77
The sequences of physics concepts form the most difficult to the easiest	Optics	4.58
	Magnet	6.87
	Heat	12.98
	Force	15.27
	Electricity	17.56
	Earth Science	19.08
	Simple Mechanical Device	23.66
Ready to face the SCK	Yes	19.08
	Doubt	57.25
	No	23.66

Table 5 shows only a few pre-service teachers give the responses that they understand about the SCK. The majority of them doubt that they understand the SCK. It is in line with their test results in table 3. And based on their responses the most difficult concepts is about the optics because some of them explain that the forgot about the optics concepts, whereas what is being tested is about the concepts of primary and high school levels and the easiest is the simple mechanical device because the problem given is a simple calculation of the mechanical advantage of a device. But, on average, pre-service teachers need to improve their knowledge about essential science concepts, especially physics.

Pre-service teachers are a determinant of the quality of science education in the future. They will become teachers who teach students. If the science teachers possess superficial SCK, they may deliver erroneous content, which can lead to some students developing misconceptions [13]. And when the teachers have the SCK like this, they might fail to challenge students' understanding or misunderstanding of SCK, which could result in superficial learning [16].

The result of this study consists of a previous study that discusses the primary school teacher/pre-service teacher is need to be improved [11] [17] [18]. This study focuses on pre-service teachers because it will be easier to learn and change their SCK according to scientific concepts. A study conducted by Widodo et al [6] found that even experienced teachers seem that increasing age and experience have little impact on the improvement of teachers' understanding.

In education, primary school teachers hold an essential role in every lesson, including science. People's expectations for primary school teachers have been incredibly high: they are responsible for teaching a wide array of subjects and doing well [19]. Gaps in teachers' science content knowledge have contributed to teachers' ineffectiveness in delivery of the science curriculum at the primary level [16] and McConnell et al reported that a significant number of studies had conducted, which provide evidence to suggest that primary school teachers lack science content knowledge [20].

This study had the same result as the study conducted by Diamond et al [21] in a large district in the South-eastern United stated. The study gives them a test instrument were developed by the National Assessment of Educational Programs (NAEP) and Teachers' performance on this test yielded a mean of 30.81 out of 38 possible points, or 81.1% correct found that SCK of primary teachers' score was not satisfactory because the instrument was designed for grade 5th. In line with that study, Mellu & Baok [22] found that the pre-service teachers in physics education also experienced the misconception 18%, did not understand concepts 30%, partially understood 40%, and only 12% fully understood.

This study also reveals that even pre-service teachers learn about science at least form 9 – 12 years, but they can't prove that they were learning it optimally. The average of all physics subjects that tested pre-service teachers just got 47% of 100%. This study also draws the condition about why they chose to be primary teachers. They think it is easy to teach students at this level because the content is at the basic/essential level and not complicated to learn. But the fact is the primary teachers play a significant role in introducing science to the students. They must have a good understanding of the essential physics/science to deliver a good quality of learning science and building for the next educational level.

Pre-service teachers are future teachers who will determine the quality of learning in the future. Then they must be prepared to face what it takes to become professional teachers. The general trend seems to be that primary school teachers tend to have major gaps in their SCK, and that these gaps are a major obstacle to effective teaching [23]. This is, in part, due to poor science preparation in preservice teacher programs.

Teacher content knowledge is a fundamental component of the teacher's effectiveness in giving a lesson [21] [23]. Previous studies suggest that there is a direct correlation between teachers' science content knowledge and teachers' effectiveness in delivering science instruction [16] [24]. However, SCK not the only element of teachers' effectiveness. Other qualities determine teachers' effectiveness [21]. The professional teachers also must have the ability to package SCK into forms that students can understand. On the other hand, teachers cannot explain to students what they do not know, thus, rendering content

knowledge a critical component of science teacher effectiveness [23].

Teachers' SCK will become their knowledge and perceptions, affecting student achievement [21]. Therefore, in the pre-service lecture process, it is necessary to provide a Professional Development which includes all parts needed by a teacher ranging from pedagogics, knowledge content, conceptual visual representations following scientific conceptions and student development, technology and other things that are a unity in the science learning process, so that science learning becomes easier to understand and enjoyable to learn from an early age [25] [26].

CONCLUSION AND SUGGESTION

This study shows that primary pre-service teachers SCK about the essentials of physics/science concepts need to improve in every physics concept because most are in the "Less" category. The study also reveals that only a few of the pre-service teachers are understand and ready to face the SCK. Some of them are in "Doubt" and "Not" understand and prepared to face the SCK in primary school. The SCK is a crucial part for teachers to give good quality of learning and build and prepare students to meet the next educational level. And SCK not only element to be a professional teacher, but they must also combine it with another component such as pedagogic, technology, etc. therefore, in the learning process or lecture process, it is necessary to develop SCK for students. The way that can be used to optimize this is by teaching science/physics from an early age must be taught conceptually and presented with appropriate representations to make it easier for students to learn.

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